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Umemoto et al.

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(54) **POLISHING APPARATUS AND POLISHING METHOD**

(71) Applicant: **EBARA CORPORATION**, Tokyo (JP)

(72) Inventors: **Masao Umemoto**, Tokyo (JP); **Tadakazu Sone**, Tokyo (JP); **Hideo Aizawa**, Tokyo (JP); **Ryuichi Kosuge**, Tokyo (JP); **Masaaki Eriguchi**, Tokyo (JP)

(73) Assignee: **Ebara Corporation**, Tokyo (JP)

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B24B 37/04 (2012.01)

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CPC ***B24B 53/017*** (2013.01); ***B24B 37/04*** (2013.01)

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USPC 451/56, 72, 443, 444, 450, 451, 488; 222/108
See application file for complete search history.

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Primary Examiner — Monica Carter
Assistant Examiner — Marcel Dion
(74) *Attorney, Agent, or Firm* — Baker & Hostetler LLP

(57) **ABSTRACT**

A polishing apparatus includes: a rotatable polishing table for supporting a polishing pad having a polishing surface; a top ring head having a top ring; a top ring head cover surrounding the top ring head; a dresser head having a dresser configured to dress the polishing surface; a dresser head cover surrounding the dresser head; a spray nozzle configured to spray a cleaning liquid onto an upper surface of the top ring and an outer surface of the top ring head cover when the top ring is in the substrate transfer position; and a spray nozzle configured to spray a cleaning liquid onto an outer surface of the dresser head cover when the dresser is in the retreated position.

6 Claims, 13 Drawing Sheets

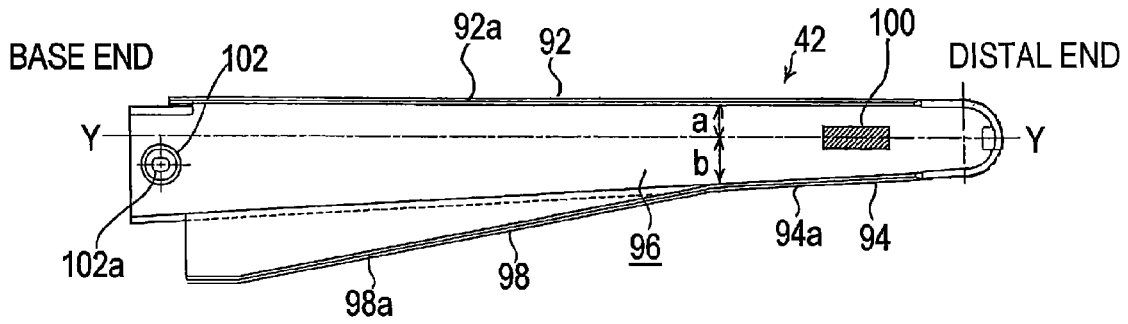

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FIG. 1

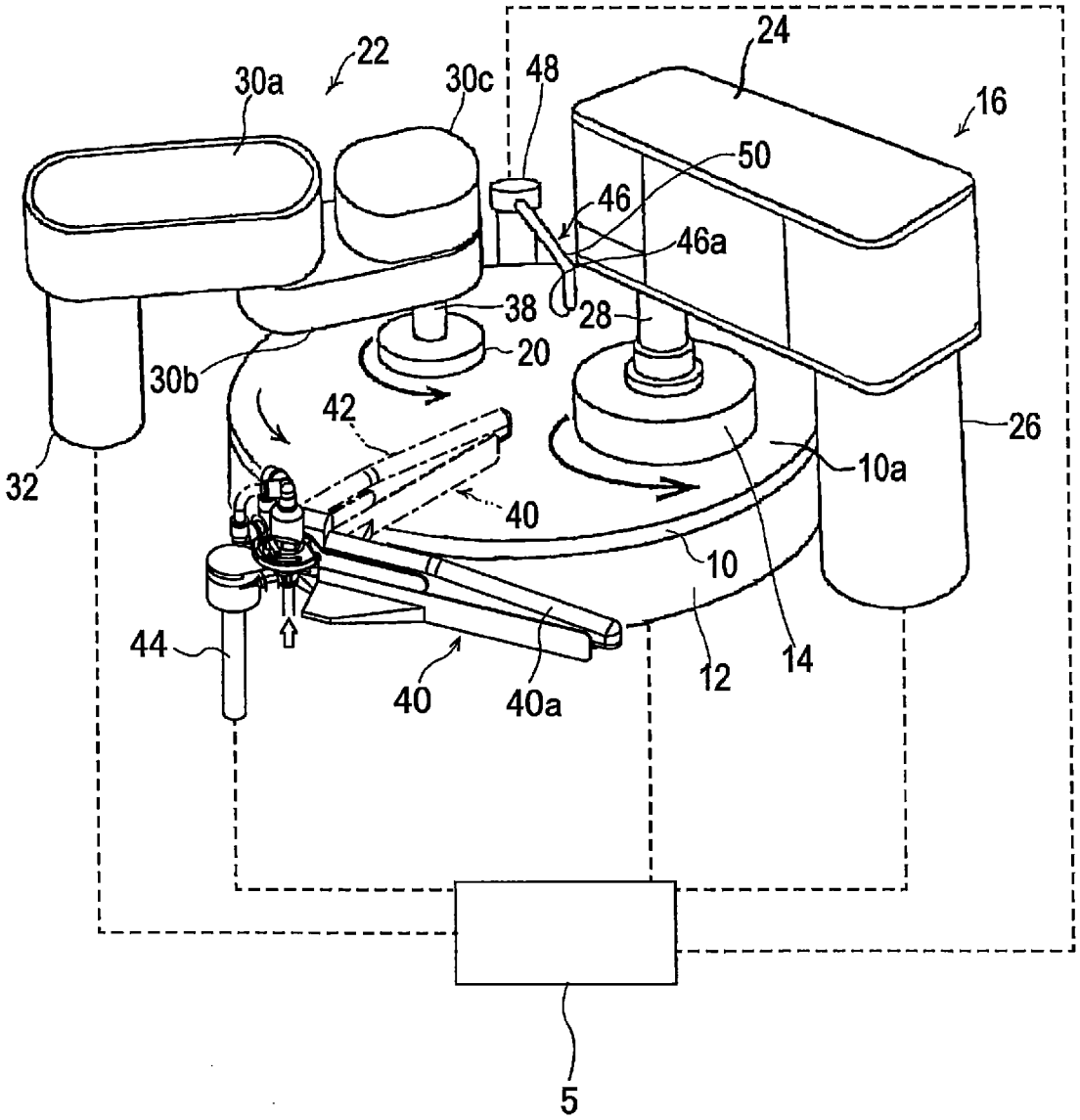
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FIG. 2

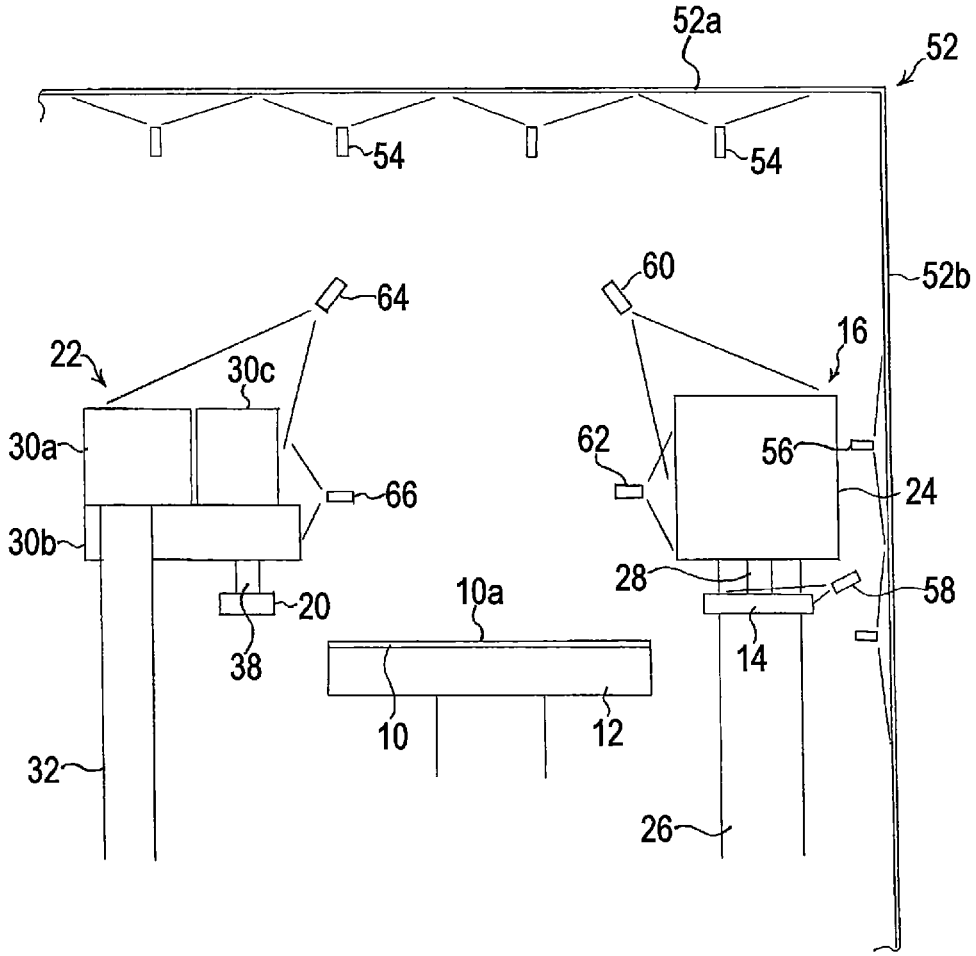
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FIG. 3

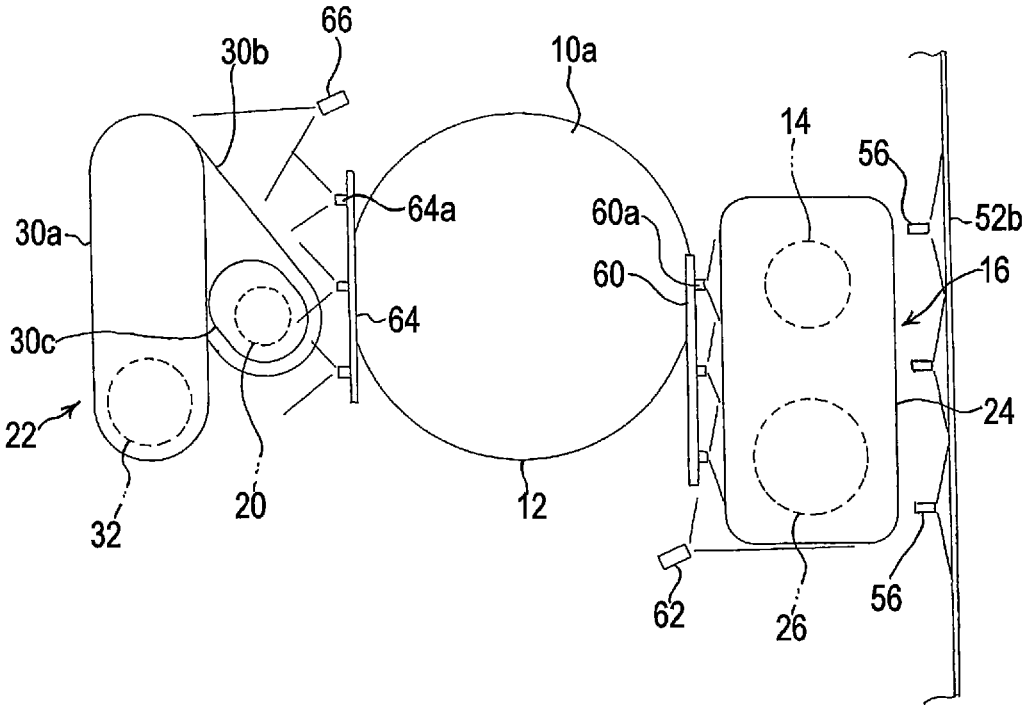


FIG. 4

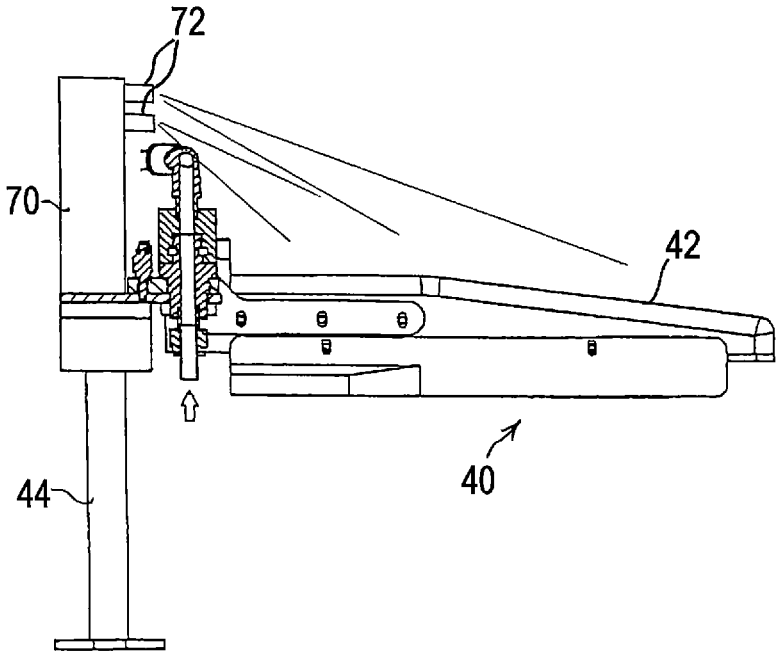


FIG. 5

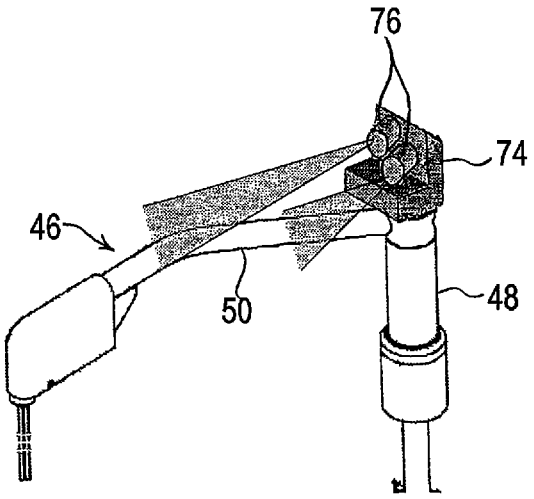


FIG. 6

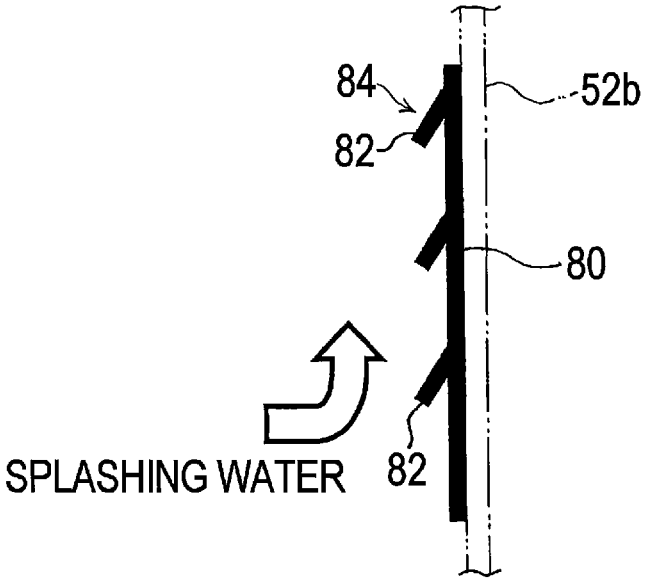
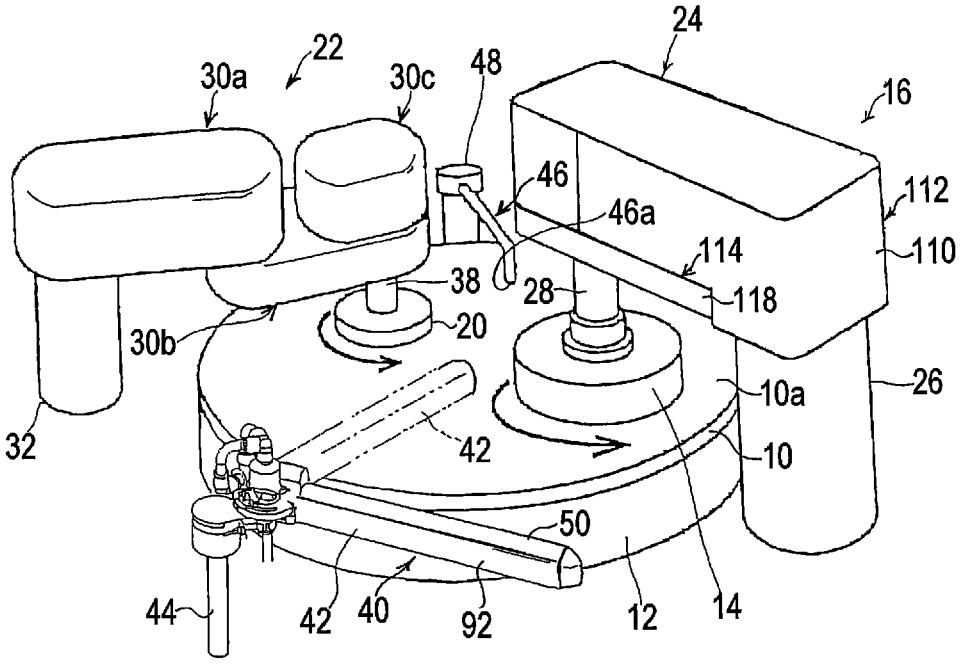


FIG. 7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114
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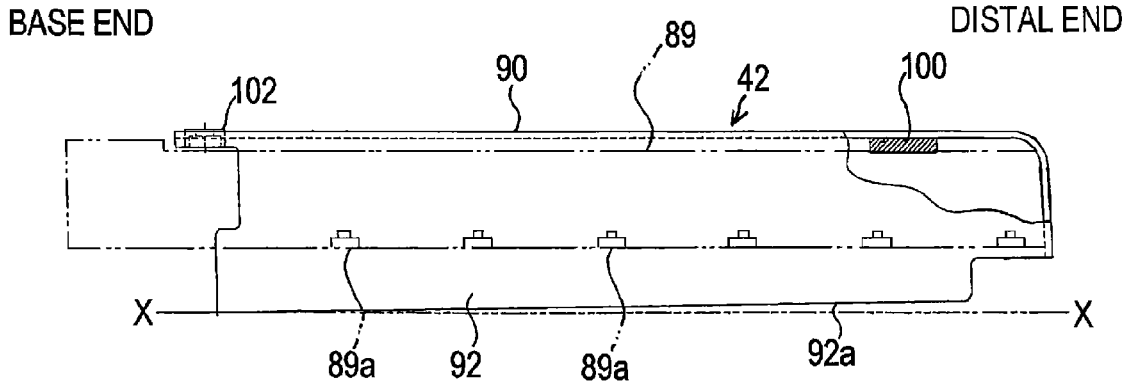
14

FIG. 8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92
89a
92a

FIG. 9

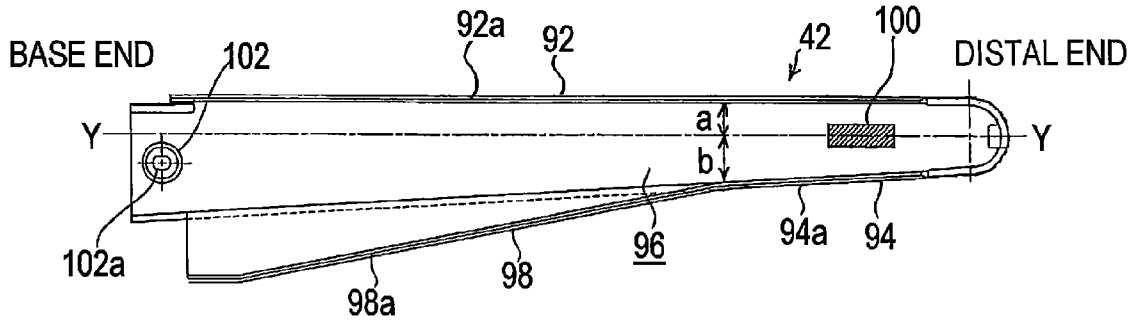
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FIG. 10

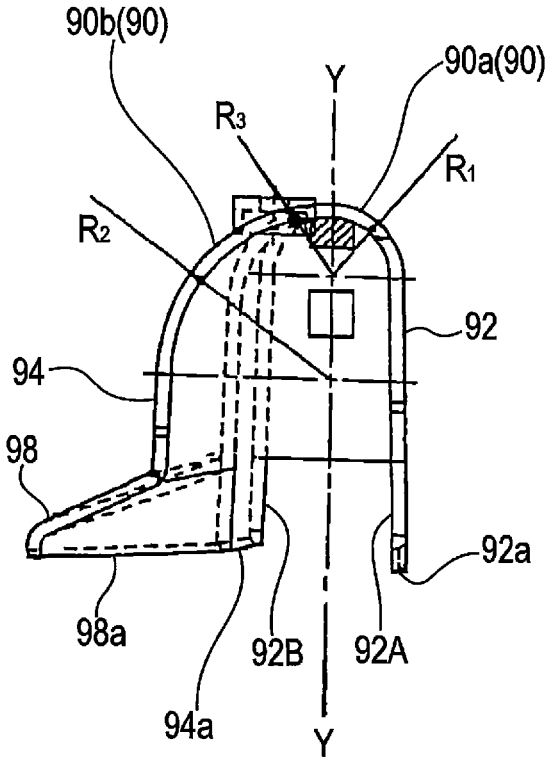


FIG. 11

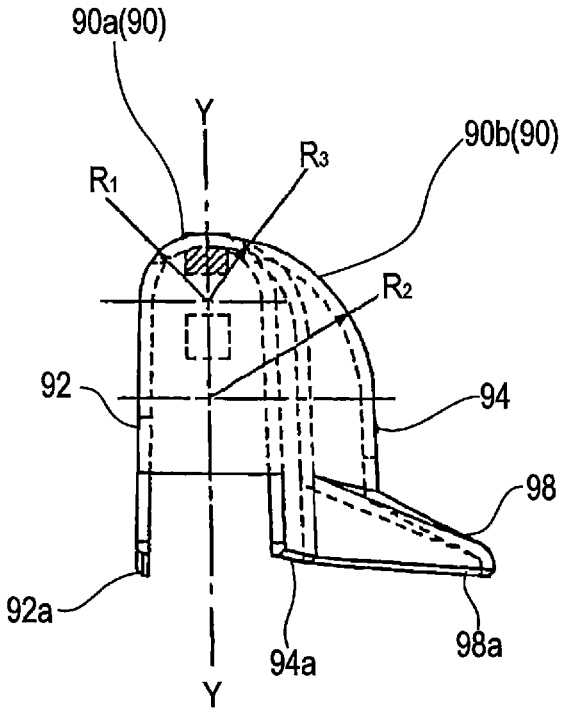


FIG. 12

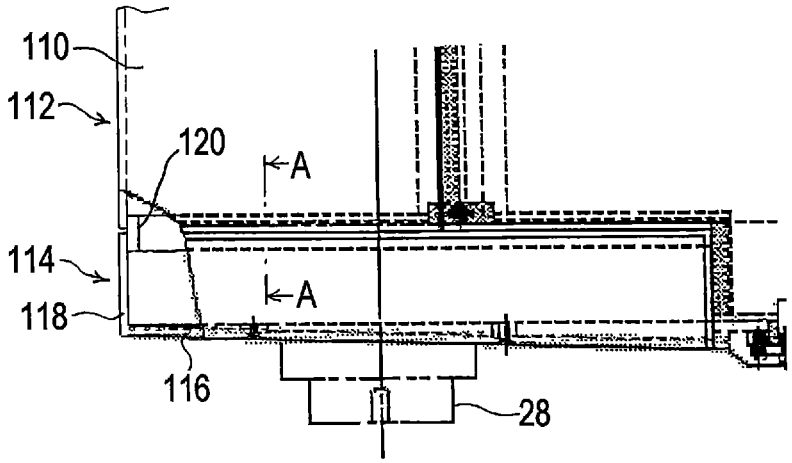


FIG. 13

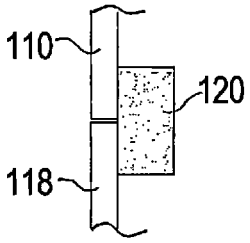


FIG. 14

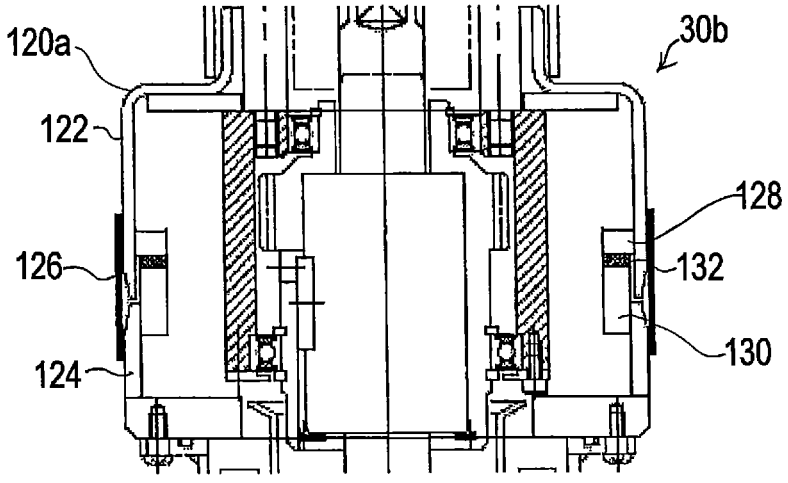
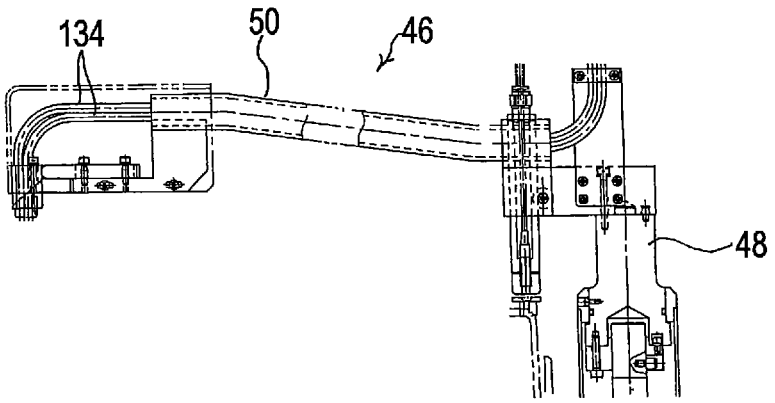


FIG. 15



POLISHING APPARATUS AND POLISHING METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This document claims priorities to Japanese Patent Application Number 2012-240394, filed Oct. 31, 2012 and Japanese Patent Application Number 2012-242951, filed Nov. 2, 2012, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a polishing apparatus and a polishing method, and more particularly to a polishing apparatus and a polishing method for polishing and planarizing a surface of a polishing object (substrate), such as a wafer, while preventing the formation of scratches on the surface of the polishing object, caused by a polishing liquid that has been scattered and dried.

The present invention also relates to a polishing apparatus, and more particularly to a polishing apparatus for polishing and planarizing a surface of a polishing object (substrate), such as a wafer, while preventing a polishing liquid from contaminating various covers and other parts disposed around a polishing table.

2. Description of the Related Art

A polishing apparatus for polishing a wafer surface generally includes a polishing table for supporting a polishing pad having a polishing surface, and a top ring (or a polishing head) for holding a wafer. While the polishing table and the top ring are moved relative to each other, the wafer, held by the top ring, is pressed against the polishing surface of the polishing pad at a predetermined pressure to come into sliding contact with the polishing surface. As a result, the wafer is polished to have a flat mirror surface. In the case of chemical mechanical polishing (CMP), a polishing liquid (or slurry) is supplied onto the polishing pad during polishing.

When the surface of the substrate, such as a wafer, is polished while the polishing liquid is supplied to the polishing pad, the polishing liquid is scattered around the polishing table. After the polishing of the substrate, a liquid (e.g., pure water) or a mixed fluid of a liquid (e.g., pure water) and a gas (e.g., nitrogen gas) is sprayed in a mist state from an atomizer to the polishing surface of the polishing pad to clean the polishing surface. During the cleaning of the polishing surface by means of the atomizer, the polishing liquid remaining on the polishing surface is also scattered around the polishing table. The scattered polishing liquid can be attached to and dried on various constituent parts disposed around the polishing table or on an inner surface of a chamber in which the polishing apparatus is housed. If the dried polishing liquid falls onto the polishing table, the fallen matters may cause a scratch on the substrate.

In general, various cleaning nozzles are disposed in predetermined positions in the polishing apparatus. A cleaning liquid is periodically emitted from the cleaning nozzles toward predetermined sites in the polishing apparatus in order to rinse off the polishing liquid that has been attached to the polishing table or the surfaces of constituent parts disposed around the polishing table. However, despite the rinsing with the cleaning liquid, some polishing liquid may remain and be dried on the surfaces of the constituent parts disposed around the polishing table. Once the polishing liquid is attached to and dried on the surfaces of the constituent parts, it is difficult to rinse off the dried polishing liquid with the cleaning liquid. Moreover, if the dried polishing liquid is deposited repeatedly, the dried polishing liquid may fall onto the polishing pad, thus causing a scratch on the substrate.

A top ring head cover that surrounds a top ring head having the top ring may be employed to protect the top ring head from the scattered polishing liquid. The polishing apparatus typically includes a dresser for dressing the polishing surface. A dressing head cover that surrounds a dressing head having the dresser may be employed to protect the dressing head from the scattered polishing liquid. Further, an atomizer cover that surrounds spray nozzle(s) of the atomizer may be employed to prevent dispersion of the mixed fluid or the polishing liquid that has bounced off the polishing pad.

The atomizer cover generally has a fairly complicated shape. As a result, a liquid containing the polishing liquid, which has bounced off the polishing pad, is likely to stay in the atomizer cover. In addition, since the atomizer cover has a number of corners where the liquid is likely to remain, it is generally difficult to clean an external surface of the atomizer cover with a cleaning liquid. If the liquid containing the polishing liquid is attached to and solidified on the atomizer cover, the solid matter may fall onto the polishing surface, thus contaminating the polishing surface.

It is difficult to completely prevent the scattered polishing liquid from flowing into the top ring head cover. Thus, the polishing liquid may enter the interior of the top ring head cover and stay there, thus contaminating the top ring head cover or the top ring head. Further, the polishing liquid may drop from the top ring head cover onto the polishing surface, thus contaminating the polishing surface.

SUMMARY OF THE INVENTION

It is a first object of the present invention to provide a polishing apparatus and a polishing method which can prevent a polishing liquid, scattered around a polishing table e.g., during polishing of a substrate, from being attached to and dried on surfaces of various constituent parts disposed around the polishing table to thereby prevent formation of scratches on a substrate surface.

It is a second object of the present invention to provide a polishing apparatus having an atomizer cover which can prevent a liquid, which has bounced off a polishing surface, from remaining on an inner surface of the atomizer cover, which is relatively easy to be cleaned with a cleaning liquid, and which can prevent a solid matter from falling onto and contaminating the polishing surface.

It is a third object of the present invention to provide a polishing apparatus having a top ring head cover which can prevent a polishing liquid from contaminating the top ring head cover or a top ring head even if the polishing liquid has entered the interior of the top ring head cover, and in addition can prevent the polishing liquid from dropping onto and contaminating a polishing surface.

An embodiment of the polishing apparatus includes: a rotatable polishing table for supporting a polishing pad having a polishing surface; a top ring head having a top ring configured to press a substrate against the polishing surface, the top ring being movable between a polishing position above the polishing table and a substrate transfer position beside the polishing table; a top ring head cover surrounding the top ring head; a dresser head having a dresser configured to dress the polishing surface, the dresser being movable between a dressing position above the polishing table and a retreated position beside the polishing table; a dresser head cover surrounding the dresser head; a spray nozzle configured

to spray a cleaning liquid onto an upper surface of the top ring and an outer surface of the top ring head cover when the top ring is in the substrate transfer position; and a spray nozzle configured to spray a cleaning liquid onto an outer surface of the dresser head cover when the dresser is in the retreated position.

According to the above-described embodiment, when the top ring is in the substrate transfer position, the cleaning liquid is sprayed from the spray nozzle onto the upper surface of the top ring and the outer surface of the top ring head cover to keep these surfaces in a wet state. Further, when the dresser is in the retreated position, the cleaning liquid is sprayed from the spray nozzle onto the outer surface of the dresser head cover to keep this outer surface in a wet state. The polishing liquid can therefore be prevented from being attached to and dried on the upper surface of the top ring, the outer surface of the top ring head cover, and the outer surface of the dresser head cover.

In a preferred embodiment, the polishing apparatus may further include: an atomizer configured to spray a cleaning fluid onto the polishing surface to clean the polishing surface; and a spray nozzle configured to spray a cleaning liquid onto an outer surface of the atomizer.

According to this embodiment, the cleaning liquid is sprayed from the spray nozzle onto the outer surface of the atomizer when a substrate is not being polished, e.g., when the polishing surface is being cleaned with the cleaning fluid sprayed from the atomizer, or when the polishing surface is being dressed by the dresser. By thus keeping the outer surface of the atomizer in a wet state with the cleaning liquid, the polishing liquid can be prevented from being attached to and dried on the surface.

In a preferred embodiment, the polishing apparatus may further include a polishing liquid supply nozzle configured to supply a polishing liquid onto the polishing surface; and a spray nozzle configured to spray a cleaning liquid onto the polishing liquid supply nozzle.

According to this embodiment, the cleaning liquid is sprayed from the spray nozzle onto the polishing liquid supply nozzle when the substrate is not being polished, e.g., when the polishing surface is being cleaned with the cleaning fluid sprayed from the atomizer or when the polishing surface is being dressed by the dresser. By thus keeping the outer surface of the polishing liquid supply nozzle in a wet state with the cleaning liquid, the polishing liquid can be prevented from being attached to and dried on the surface.

In a preferred embodiment, the polishing apparatus may further include a spray nozzle configured to spray a cleaning liquid onto an inner surface of a chamber in which the polishing apparatus is housed.

According to this embodiment, the cleaning liquid is sprayed from the spray nozzle onto the inner surface of the chamber when the substrate is not being polished. By thus keeping the inner surface of the chamber in a wet state with the cleaning liquid, the polishing liquid can be prevented from being attached to and dried on the surface.

Another embodiment of the polishing method includes moving a top ring, holding a substrate, to a polishing position above a polishing table; rotating the polishing table; pressing the substrate against a polishing surface of a polishing pad on the polishing table by the top ring while supplying a polishing liquid from a polishing liquid supply nozzle onto the polishing surface to polish the substrate; moving the top ring, holding the polished substrate, from the polishing position to a substrate transfer position beside the polishing table; and spraying a cleaning liquid onto an upper surface of the top ring and an outer surface of a top ring head cover surrounding a top ring head having the top ring.

In a preferred embodiment, the polishing method may further include: moving a dresser to a dressing position above the polishing table when the top ring is in the substrate transfer position; pressing the dresser against the polishing surface to dress the polishing surface; moving the dresser from the dressing position to a retreated position beside the polishing table; and spraying a cleaning liquid onto an outer surface of a dresser head cover surrounding a dresser head having the dresser.

In a preferred embodiment, the polishing method may further include spraying a cleaning fluid from an atomizer onto the polishing surface to clean the polishing surface while spraying a cleaning liquid onto an outer surface of the atomizer when the substrate is not being polished.

In a preferred embodiment, the polishing method may further include spraying a cleaning liquid onto the polishing liquid supply nozzle when the substrate is not being polished.

Still another embodiment of the polishing apparatus includes: a rotatable polishing table for supporting a polishing pad having a polishing surface; an atomizer head configured to spray a cleaning fluid onto the polishing surface to clean the polishing surface; and an atomizer cover that covers an upper surface of the atomizer head. The atomizer cover includes a semicylindrical top plate having a semicylindrical shape, and a first side plate and a second side plate extending downward from both lower ends of the semicylindrical top plate. The semicylindrical top plate includes a first top plate having a vertical cross section in a shape of arc whose radius is constant over its entire length from a base end to a distal end of the atomizer cover, and a second top plate having a vertical cross section in a shape of arc whose radius decreases gradually from the base end toward the distal end of the atomizer cover. The first top plate and the second top plate are connected to each other at their top portions to constitute the semicylindrical top plate.

According to this embodiment, the atomizer cover has a smooth shape with no angular portion so that a liquid, which has come into contact with the inner or outer surface, will easily run down. Such a shape can prevent the contamination of the atomizer cover with a liquid containing the polishing liquid. Even if a liquid containing the polishing liquid has adhered to the atomizer cover, the liquid can be easily removed. It therefore becomes possible to prevent a liquid containing the polishing liquid from being solidified on the inner surface or the outer surface of the atomizer cover, thereby preventing a solid matter from falling onto and contaminating the polishing surface.

In a preferred embodiment, the semicylindrical top plate, the first side plate, and the second side plate are formed integrally from resin.

The atomizer cover, because of its smooth shape with no angular portion, can be produced by integral molding of a resin.

In a preferred embodiment, the semicylindrical top plate, the first side plate, and the second side plate are formed integrally from resin.

According to the embodiment, the atomizer cover can be designed so that a liquid, which has flowed down the semicylindrical top plate and one of the side plates, and reached the lower end surface of the side plate, is allowed to flow on the lower end surface in a direction from the distal end to the base end of the atomizer cover.

In a preferred embodiment, the second side plate is connected to the second top plate, and the second side plate is provided with a projecting portion projecting in a horizontal direction.

By providing the projecting portion integrally to the second side plate, the atomizer cover can be reinforced with the projecting portion. Furthermore, the projecting portion can prevent the disperse of the liquid.

In a preferred embodiment, the polishing apparatus may further include a top ring head having a top ring configured to press a substrate against the polishing surface while holding and rotating the substrate; and a top ring head cover surrounding the top ring head. The top ring head cover includes a side cover that surrounds the top ring head, and a lower cover that closes a bottom opening of the side cover. The lower cover includes a bottom plate inclined downwardly toward a radially outward direction of the polishing table when the top ring is in a polishing position above the polishing table.

According to this embodiment, the polishing liquid that has entered the interior of the top ring head cover reaches the bottom plate of the lower cover, flows on the inclined bottom plate, and is collected at a place lying beside the polishing table. This can prevent the polishing liquid from contaminating the top ring head cover and the top ring head, and dropping onto and contaminating the polishing surface.

In a preferred embodiment, the lower cover includes a side plate which extends upwardly from a peripheral portion of the bottom plate and which is in contact with or in proximity to a side plate of the side cover.

According to this embodiment, a coupling portion between the side cover and the lower cover can be located at a higher position than a corner between the side cover and the lower cover. This configuration can prevent the polishing liquid from remaining in the corner.

According to the above-described polishing apparatus, constituent parts disposed around the polishing table, such as the upper surface of the top ring, the outer surface of the top ring head cover, and the outer surface of the dresser head cover, can be kept in a wet state. Therefore, it is possible to prevent the polishing liquid from being attached to and dried on the constituent parts to thereby prevent the dried polishing liquid from falling onto the polishing table and causing a scratch on the substrate.

The above-described polishing apparatus can prevent the contamination of the atomizer cover with a liquid containing the polishing liquid. Even if a liquid containing the polishing liquid has adhered to the atomizer cover, the liquid can be easily removed. It therefore becomes possible to prevent a liquid containing the polishing liquid from being solidified on the inner surface or the outer surface of the atomizer cover to thereby prevent a solid matter from falling onto and contaminating the polishing surface. Further, even if the polishing liquid has entered the interior of the atomizer cover, the polishing liquid can be prevented from contaminating the top ring head cover or the top ring head and, in addition, can be prevented from dropping onto and contaminating the polishing surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing a polishing apparatus according to an embodiment of the present invention when a top ring is in a polishing position above a polishing table and a dresser is in a dressing position above the polishing table;

FIG. **2** is a front view showing the polishing apparatus of FIG. **1**, together with spray nozzles, when the top ring is in a substrate transfer position beside the polishing table and the dresser is in a retreated position beside the polishing table;

FIG. **3** is a plan view showing the polishing apparatus of FIG. **1**, together with the spray nozzles, when the top ring is in the substrate transfer position beside the polishing table and the dresser is in the retreated position beside the polishing table;

FIG. **4** is a front view showing spray nozzles and an atomizer provided in the polishing apparatus shown in FIG. **1**;

FIG. **5** is a perspective view showing spray nozzles and a polishing liquid supply nozzle provided in the polishing apparatus shown in FIG. **1**;

FIG. **6** is a cross-sectional view showing a waterproof plate provided on a surrounding wall of a chamber;

FIG. **7** is a perspective view showing the polishing apparatus according to another embodiment of the present invention;

FIG. **8** is a front view of an atomizer cover, with an atomizer head depicted by imaginary line;

FIG. **9** is a bottom view of the atomizer cover;

FIG. **10** is a left side view of the atomizer cover of FIG. **8**;

FIG. **11** is a right side view of the atomizer cover of FIG. **8**;

FIG. **12** is an enlarged front view of a lower cover of a top ring head cover;

FIG. **13** is a cross-sectional view taken along line A-A in FIG. **12**;

FIG. **14** is a vertical cross-sectional view of a second dresser head cover; and

FIG. **15** is a perspective view showing details of the polishing liquid supply nozzle.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described with reference to the drawings. FIG. **1** is a perspective view of a polishing apparatus according to an embodiment of the present invention. FIG. **1** shows the polishing apparatus when a top ring **14** is in a polishing position above a polishing table **12** and a dresser **20** is in a dressing position above the polishing table **12**. Depiction of spray nozzles is omitted in FIG. **1**.

As shown in FIG. **1**, the polishing apparatus includes a polishing pad **10** whose upper surface serves as a polishing surface **10***a*, a polishing table **12** with the polishing pad **10** attached to an upper surface thereof, a top ring head **16** having a top ring **14** for bringing a substrate (polishing object), such as a wafer, into sliding contact with the polishing surface (upper surface) **10***a* of the polishing pad **10** to polish the substrate, and a dresser head **22** having a dresser **20** for conditioning (or dressing) the polishing surface **10***a* of the polishing pad **10**. The polishing table **12** is coupled to a not-shown motor, so that the polishing table **12** and the polishing pad **10** are rotated in a direction shown by arrow by means of the motor.

Elements of the top ring head **16**, excepting the top ring **14**, are surrounded by a top ring head cover **24**. The top ring head **16** is coupled to an upper end of a rotatable top ring head pivot shaft **26**. This top ring head pivot shaft **26** extends upward through a bottom plate of the top ring head cover **24**. The top ring **14** is coupled to a lower end of a top ring drive shaft **28** that extends downward through the bottom plate of the top ring head cover **24**. The top ring **14** has a lower surface that constitutes a substrate holding surface for holding a substrate by e.g., vacuum suction.

As the top ring head **16** pivots by the rotation of the top ring head pivot shaft **26**, the top ring **14** moves between the pol-

ishing position just above the polishing table **12**, shown in FIG. **1**, and a substrate transfer position beside the polishing table **12**, shown in FIGS. **2** and **3**.

Elements of the dresser head **22**, excepting the dresser **20**, are surrounded by three dresser head covers: a first dresser head cover **30***a*; a second dresser head cover **30***b*; and a third dresser head cover **30***c*. The dresser head **22** is coupled to an upper end of a rotatable dresser head pivot shaft **32** that extends upward through a bottom plate of the first dresser head cover **30***a*. The dresser **20** is coupled to a lower end of a dresser drive shaft **38** that extends downward through a bottom plate of the second dresser head cover **30***b*.

As the dresser head **22** pivots by the rotation of the dresser head pivot shaft **32**, the dresser **20** moves between the dressing position just above the polishing table **12**, shown in FIG. **1**, and a retreated position beside the polishing table **12**, shown in FIGS. **2** and **3**.

An atomizer **40** is disposed adjacent to the polishing table **12**. The atomizer **40** is configured to spray (or eject) a cleaning fluid, such as a liquid (e.g., pure water) or a mixed fluid of a liquid (e.g., pure water) and a gas (e.g., nitrogen gas), in a mist form onto the polishing surface **10***a* of the polishing pad **10** so as to clean the polishing surface **10***a*. The atomizer **40** has its upper surface composed of an atomizer cover **42**. A large number of jet orifices (not shown) for emitting the cleaning fluid downward are provided in a lower surface of the atomizer **40** at predetermined intervals along a longitudinal direction of the atomizer **40**. The atomizer **40** is coupled to an upper end of an atomizer pivot shaft **44** so that, as the atomizer pivot shaft **44** rotates, the atomizer **40** pivots between a retreated position beside the polishing table **12**, shown by solid line in FIG. **1**, and a cleaning position above the polishing table **12**, shown by imaginary line in FIG. **1**.

A polishing liquid supply nozzle **46** is disposed adjacent to the polishing table **12**. The polishing liquid supply nozzle **46** is configured to supply a polishing liquid (or slurry) through a supply orifice **46***a*, which is provided at a distal end thereof, onto the polishing surface **10***a* of the polishing pad **10**. The polishing liquid supply nozzle **46** is coupled to an upper end of a nozzle pivot shaft **48** so that, as the nozzle pivot shaft **48** rotates, the polishing liquid supply nozzle **46** pivots between a polishing liquid supply position, shown in FIG. **1**, where the supply orifice **46***a* is located above the polishing table **12** and a retreated position (not shown) where the supply orifice **46***a* is located beside the polishing table **12**. In this embodiment the polishing liquid supply nozzle **46** is constituted by a single pipe **50** and a plurality of polishing liquid tubes housed in the pipe **50**.

The polishing table **12**, the top ring head **16**, the dresser head **22**, the atomizer **40**, and the polishing liquid supply nozzle **46** are coupled to an operation controller **5**, which is configured to control the operations of these elements.

As shown in FIGS. **2** and **3**, the polishing apparatus is housed in a chamber **52**. Spray nozzles are disposed in the chamber **52** for spraying a cleaning liquid, such as pure water, onto an inner surface of the chamber **52**. More specifically, the spray nozzles include ceiling spray nozzles **54** for spraying a cleaning liquid onto a ceiling **52***a* and surrounding wall spray nozzles **56** for spraying a cleaning liquid onto a surrounding wall **52***b*.

A top ring spray nozzle **58** is disposed in the chamber **52**. This top ring spray nozzle **58** is configured to spray a cleaning liquid onto the upper surface of the top ring **14** when the top ring **14** is in the substrate transfer position beside the polishing table **12**. The top ring spray nozzle **58** is disposed obliquely above the top ring **14** in the substrate transfer position. Further, spray nozzles for spraying a cleaning liquid onto the outer surface of the top ring head cover **24** are disposed in the chamber **52**. More specifically, an upper spray nozzle **60** is provided for spraying a cleaning liquid onto a polishing-table-side surface of the top ring head cover **24** from obliquely above, and a side spray nozzle **62** is provided for spraying a cleaning liquid horizontally toward the polishing-table-side surface of the top ring head cover **24**. The upper spray nozzle **60** has a large number of jet orifices **60***a* arranged horizontally along a longitudinal direction of the upper spray nozzle **60**.

Further, spray nozzles are disposed in the chamber **52** for spraying a cleaning liquid onto the outer surfaces of the dresser head covers **30***a*, **30***b*, **30***c* when the dresser **20** is in the retreated position beside the polishing table **12**. More specifically, an upper spray nozzle **64** is provided for spraying a cleaning liquid onto polishing-table-side surfaces of the dresser head covers **30***a*, **30***b*, **30***c* from obliquely above, and a side spray nozzle **66** is provided for spraying a cleaning liquid horizontally toward the polishing-table-side surfaces of the dresser head covers **30***a*, **30***b*, **30***c*. The upper spray nozzle **64** has a large number of jet orifices **64***a* arranged horizontally along a longitudinal direction of the upper spray nozzle **64**.

As shown in FIG. **4**, a bracket **70** is coupled to the upper end of the atomizer pivot shaft **44** so that the bracket **70** rotates together with the atomizer pivot shaft **44**. Spray nozzles **72** are mounted to the bracket **70**. These spray nozzles **72** are provided for spraying a cleaning liquid onto the atomizer cover **42** in its entirety both when the atomizer cover **42** is in the cleaning position and when the atomizer cover **42** is in the retreated position. Two spray nozzles **72** are provided in the illustrated embodiment.

As shown in FIG. **5**, a bracket **74** is coupled to the upper end of the nozzle pivot shaft **48** so that the bracket **74** rotates together with the nozzle pivot shaft **48**. Spray nozzles **76** are mounted to the bracket **74**. These spray nozzles **76** are provided for spraying a cleaning liquid onto the polishing liquid supply nozzle **46** in its entirety, i.e., the outer surface of the pipe **50**, when the supply orifice **46***a* of the polishing liquid supply nozzle **46** is in the retreated position beside the polishing table **12**. Two spray nozzles **76** are provided in the illustrated embodiment.

The operations of the above-described spray nozzles **54**, **56**, **58**, **60**, **62**, **64**, **66**, **72**, **76**, including the start and stop of spraying of the cleaning liquid, are controlled by the operation controller **5**.

An operational sequence of the above-described polishing apparatus will now be described. The operational sequence is controlled by the operation controller **5** according to an operation recipe that is preset in the operation controller **5**. When the top ring **14** is in the substrate transfer position, the top ring **14** receives a substrate. The top ring **14** is then moved to the polishing position above the polishing table **12**. While the top ring **14** is rotating the substrate, the top ring **14** lowers the substrate and brings the substrate into contact with the polishing surface **10***a* of the rotating polishing pad **10**, so that the substrate is polished. During the polishing of the substrate, the polishing liquid is supplied onto the polishing surface **10***a* from the polishing liquid supply nozzle **46** that has been moved from the retreated position to the polishing liquid supply position.

After the polishing of the substrate is terminated, the top ring **14** is raised and then moved to the substrate transfer position beside the polishing table **12**. The polished substrate is transferred for the next process step. Simultaneously, the polishing liquid supply nozzle **46** is moved from the polishing liquid supply position to the retreated position.

After the polishing of the substrate is terminated, the dresser **20** is moved from the retreated position to the dressing position. While the dresser **20** is rotated, the dresser **20** is lowered to bring its lower surface into contact with the polishing surface **10***a* of the rotating polishing pad **10**, thereby rubbing and dressing the polishing surface **10***a*. After the dressing of the polishing surface **10***a* is terminated, the dresser **20** is moved from the dressing position to the retreated position.

Further, the atomizer **40** is moved from the retreated position to the cleaning position. The cleaning fluid is then ejected from the atomizer **40** onto the polishing surface **10***a* of the polishing pad **10**, thereby cleaning the polishing surface **10***a*. After the cleaning of the polishing surface **10***a* is terminated, the atomizer **40** is moved from the cleaning position to the retreated position. Although the atomizer **40** in this embodiment is configured to be movable from the cleaning position to the retreated position, the atomizer **40** may be fixed at the cleaning position.

When the top ring **14** is in the substrate transfer position, the cleaning liquid is sprayed onto the upper surface of the top ring **14** from the top ring spray nozzle **58** disposed obliquely above the top ring **14** and, at the same time, the cleaning liquid is sprayed onto the outer surface of the top ring head cover **24** from the upper spray nozzle **60** and the side spray nozzle **62**, which are disposed around the top ring head cover **24**, thereby keeping the upper surface of the top ring **14** and the outer surface of the top ring head cover **24** in a wet state with the cleaning liquid. Since these surfaces are kept in a wet state with the cleaning liquid, the polishing liquid, when it comes into contact with the wet surfaces, can be prevented from being attached to and dried on these surfaces. Further, since the cleaning liquid is sprayed from the top ring spray nozzle **58**, the upper spray nozzle **60**, and the side spray nozzle **62** when the top ring **14** is in the substrate transfer position, the cleaning liquid that has been once sprayed does not fall onto the polishing pad **10**, and therefore does not affect the polishing performance of the polishing pad **10**.

The spraying of the cleaning liquid from the top ring spray nozzle **58**, the upper spray nozzle **60**, and the side spray nozzle **62** is stopped before the top ring **14** moves from the substrate transfer position to the polishing position. In this manner, the operation controller **5** controls the start and stop of spraying the cleaning liquid from the spray nozzles **58**, **60**, **62** based on the position of the top ring **14**.

When the dresser **20** is in the retreated position beside the polishing table **12**, the cleaning liquid is sprayed onto the outer surfaces of the dresser head covers **30***a*, **30***b*, **30***c* from the upper spray nozzle **64** and the side spray nozzle **66** disposed around the dresser head covers **30***a*, **30***b*, **30***c*, thereby keeping the outer surfaces of the dresser head covers **30***a*, **30***b*, **30***c* in a wet state. By thus keeping the surfaces in a wet state with the cleaning liquid, the polishing liquid, when it comes into contact with the wet surfaces, can be prevented from being attached to and dried on the surfaces.

The spraying of the cleaning liquid from the upper spray nozzle **64** and the side spray nozzle **66** is stopped before the dresser **20** moves from the retreated position to the dressing position. The operation controller **5** thus controls the start and stop of spraying the cleaning liquid from the upper spray nozzle **64** and the side spray nozzle **66** based on the position of the dresser **20**.

The cleaning liquid is sprayed from the spray nozzles **72** onto the outer surface of the atomizer cover **42** when a substrate is not being polished, e.g., when the polishing surface **10***a* is being cleaned with the cleaning fluid, such as the mixed fluid or the liquid, sprayed from the atomizer **40** in the cleaning position, or when the polishing surface **10***a* is being dressed by the dresser **20** while the atomizer **40** is in the retreated position. By thus keeping the outer surface of the atomizer cover **42** in a wet state with the cleaning liquid, the polishing liquid, when it comes into contact with the wet surface, can be prevented from being attached to and dried on the surface.

In particular, since the cleaning liquid is sprayed from the spray nozzles **72** onto the outer surface of the atomizer cover **42** when the polishing surface **10***a* is being cleaned with the cleaning fluid sprayed from the atomizer **40**, the cleaning fluid that has bounced off the polishing surface **10***a* can be prevented from attaching to the atomizer cover **42**.

The cleaning liquid is not sprayed onto the atomizer cover **42** when a substrate is being polished on the polishing pad **10**. In this manner, the operation controller **5** controls the start and stop of spraying of the cleaning liquid from the spray nozzles **72** based on whether a substrate is being polished or not.

As described above, the atomizer **40** may be fixed at the cleaning position and the spray nozzles **72** may spray the cleaning liquid onto the outer surface of the atomizer cover **42** when a substrate is not being polished. The cleaning liquid that covers the atomizer cover **42** can prevent a liquid, which has been scattered from the polishing pad **10** during dressing, from contacting the atomizer **40**. Although the cleaning liquid that has been sprayed from the spray nozzles **72** falls onto the polishing pad **10**, the fallen cleaning liquid is removed by the cleaning fluid that is being supplied simultaneously from the atomizer **40** to the polishing surface **10***a* and therefore does not remain on the polishing pad **10**.

The cleaning liquid is sprayed from the spray nozzles **76** onto the polishing liquid supply nozzle **46**, i.e., the pipe **50**, when the polishing liquid supply nozzle **46** is in the retreated position and a substrate is not being polished, e.g., when the polishing surface **10***a* is being cleaned with the cleaning fluid, such as the mixed fluid or the liquid, sprayed from the atomizer **40**, or when the polishing surface **10***a* is being dressed by the dresser **20**. By thus keeping the outer surface of the polishing liquid supply nozzle **46**, i.e., the pipe **50**, in a wet state with the cleaning liquid, the polishing liquid, when it comes into contact with the wet surface, can be prevented from being attached to and dried on the surface.

The spraying of the cleaning liquid from the spray nozzles **76** is stopped before the polishing liquid supply nozzle **46** moves from the retreated position to the polishing liquid supply position. In this manner, the operation controller **5** controls the start and stop of spraying the cleaning liquid from the spray nozzles **76** based on the position of the polishing liquid supply nozzle **46**.

In this embodiment the polishing liquid supply nozzle **46** is configured to be movable between the polishing liquid supply position and the retreated position. However, as with the above-described atomizer **40**, the polishing liquid supply nozzle **46** may be fixed at the polishing liquid supply position. In this case, the cleaning liquid may be sprayed onto the polishing liquid supply nozzle **46** in the polishing liquid supply position to keep it in a wet state e.g., when the polishing surface **10***a* is being cleaned with the cleaning fluid sprayed from the atomizer **40** or when the polishing surface **10***a* is being dressed by the dresser **20**.

When a substrate is not being polished, the cleaning liquid is sprayed from the ceiling spray nozzles **54** onto the ceiling **52***a* of the chamber **52**, and sprayed from the surrounding wall spray nozzles **56** onto the surrounding wall **52***b* of the chamber **52**, thereby keeping the ceiling **52***a* and the surrounding wall **52***b*, constituting the inner surface of the chamber **52**, in a wet state. By thus keeping the inner surface in a

wet state, the polishing liquid, when it comes into contact with the wet surface, can be prevented from being attached to and dried on the surface.

The cleaning liquid is not sprayed onto the ceiling **52***a* and the surrounding wall **52***b* of the chamber **52** when a substrate is being polished on the polishing pad **10**. The operation controller **5** thus controls the start and stop of spraying the cleaning liquid from the ceiling spray nozzles **54** and the surrounding wall spray nozzles **56** based on whether a substrate is being polished or not.

As shown in FIG. **6**, a waterproof plate **84** may be provided at a predetermined position on the surrounding wall **52***b* of the chamber **52**. The waterproof plate **84** includes a flat support plate **80** and a plurality of return plates **82** mounted to the support plate **80** at predetermined intervals along the vertical direction. Each return plate **82** is inclined downward. The thus-constructed waterproof plate **84** can prevent bouncing of air flow coming from the polishing pad **10**.

According to the polishing apparatus of this embodiment, the constituent parts disposed around the polishing table **12**, such as the upper surface of the top ring **14**, the outer surface of the top ring head cover **24**, and the outer surfaces of the dresser head covers **30***a*, **30***b*, **30***c*, can be kept in a wet state without any influence on processing, including polishing of the substrate. This structure can prevent the polishing liquid from being attached to and dried on the constituent parts disposed around the polishing table **12**, thus preventing the dried polishing liquid from falling onto the polishing table **12** and causing a scratch on the substrate.

Operations of the start and stop of spraying of the cleaning liquid from all of the above-described cleaning nozzles are carried out according to the operation recipe that is set in the operation controller **5**. The cleaning liquid, supplied from any of the spray nozzles onto a constituent part, can keep the constituent part in a wet state even when the polishing apparatus is in an idling operation (or a standby operation). The "idling operation" herein refers to a standby operation performed when polishing of a substrate is not carried out for a relatively long period of time. One example of the idling operation is a standby operation performed during a period of time from the completion of polishing of one lot of substrates to the start of polishing of the next lot of substrates.

In order to more effectively prevent the attachment of the polishing liquid, a water-repellent coating material may be applied to some or all of the constituent parts disposed around the polishing table **12**.

FIG. **7** is a perspective view showing the polishing apparatus according to another embodiment of the present invention. With reference to the construction and the operation of this embodiment which are the same as those of the above-described embodiment shown in FIG. **1**, a duplicate description thereof will be omitted. Depiction of the operation controller **5** is omitted in FIG. **7**.

As shown in FIG. **7**, atomizer **40** includes an atomizer head **89** (see FIG. **8**) for spraying (or ejecting) a cleaning fluid, such as a liquid (e.g., pure water) or a mixed fluid of a liquid (e.g., pure water) and a gas (e.g., nitrogen gas), in a mist form onto the polishing surface **10***a* of the polishing pad **10** to clean the polishing surface **10***a*, and atomizer cover **42** that covers an upper surface of the atomizer head **89**. A large number of spray nozzles **89***a* (see FIG. **8**) for emitting the cleaning fluid downward are provided in a lower surface of the atomizer head **89** at predetermined intervals in the longitudinal direction of the atomizer head **89**. The atomizer **40** is coupled to the upper end of the atomizer pivot shaft **44** so that, as the atomizer pivot shaft **44** rotates, the atomizer **40** pivots between the retreated position beside the polishing table **12**, shown by the solid line in FIG. **7**, and the cleaning position above the polishing table **12**, shown by the imaginary line in FIG. **7**.

FIGS. **8** through **11** show the atomizer cover **42**. In FIGS. **8** and **9**, the left side of the atomizer cover **42** is a base end of the atomizer cover **42**, and the right side of the atomizer cover **42** is a distal end of the atomizer cover **42**. As shown in FIGS. **8** through **11**, the atomizer cover **42** has a first top plate **90***a* having a vertical cross section in a shape of ¼ circle whose radius R_1 is constant, and a second top plate **90***b* having a vertical cross section in a shape of ¼ circle whose radius decreases gradually from the base end toward the distal end, i.e., a radius R_2 at the base end is larger than a radius R_3 at the distal end ($R_2 > R_3$). A top portion of the first top plate **90***a* and a top portion of the second top plate **90***b* are connected to each other to constitute a semicylindrical top plate **90** having a semicylindrical shape. The semicylindrical top plate **90** has a semicircular vertical cross section. The atomizer cover **42** has two side plates, i.e., a first side plate **92** and a second side plate **94**, continuously extending vertically downward from both lower ends of the semicylindrical top plate **90**. An upper end of the first side plate **92** is integrally connected to the lower end of the first top plate **90***a*, and an upper end of the second side plate **94** is integrally connected to the lower end of the second top plate **90***b*.

The first top plate **90***a*, the second top plate **90***b*, and the side plates **92**, **94** form an open-bottom space **96** inside the atomizer cover **42**. A vertical plane Y-Y represents an imaginary vertical plane that vertically passes through the top portions of the first top plate **90***a* and the second top plate **90***b* (i.e., the top portion of the semicylindrical top plate **90**). In the interior space **96** of the atomizer cover **42**, a distance "a" from the vertical plane Y-Y to the first side plate **92** is constant, whereas a distance "b" from the vertical plane Y-Y to the second side plate **94** decreases gradually from the base end toward the distal end. The interior space **96** of the atomizer cover **42** is asymmetric with respect to the vertical plane Y-Y. As shown in FIG. **8**, the atomizer head **89** is housed in the space **96** in such a state that the upper surface of the atomizer head **89** is covered with the atomizer cover **42**. The atomizer head **89** has the spray nozzles **89***a* for spraying the cleaning fluid, such as the liquid (e.g., pure water) or the mixed fluid of a liquid (e.g., pure water) and the gas (e.g., nitrogen gas), in a mist form onto the polishing surface **10***a* of the polishing pad **10** to clean the polishing surface **10***a*.

While in this embodiment the first top plate **90***a* and the second top plate **90***b*, each having the vertical cross section of ¼ circle, are connected together at their top portions to form the semicylindrical top plate **90**, a first top plate and a second top plate, each having a vertical cross section in a shape of arc, may be connected to each other at their top portions to form a semicylindrical top plate.

A projecting portion **98**, whose amount of outward projection decreases gradually from the base end toward the distal end, is formed integrally on the second side plate **94** that is connected to the second top plate **90***b*. The projecting portion **98** functions to prevent the cleaning fluid, which has been sprayed from the spray nozzles **89***a* onto the polishing pad **10** and bounced off the polishing pad **10**, from diffusing in the chamber **52** (see FIG. **2**). The lower end surface **94***a* of the second side plate **94**, in its portion where the projecting portion **98** is not formed, and a lower end surface **98***a* of the projecting portion **98** are connected continuously. Although in this embodiment the projecting portion **98** is provided only on the second side plate **94** connected to the second top plate **90***b*, it is possible to additionally provide a projecting portion on the first side plate **92** connected to the first top plate **90***a*.

As shown in FIG. **8**, the lower end surface **92***a* of the first side plate **92** is inclined downward with respect to a horizontal plane X-X in a direction from the distal end toward the base end of the atomizer cover **42**. Similarly, the lower end surface **94***a* of the second side plate **94** and the lower end surface **98***a* of the projecting portion **98**, connected to each other, are inclined downward in a direction from the distal end toward the base end of the atomizer cover **42**.

The atomizer cover **42** can be produced by integral molding of a resin, such as polyvinyl chloride. A draft angle in integral molding of the resin is, for example, 1.5°. Thus, in FIG. **10**, a vertical portion **92**A of the first side plate **92** connected to the first top plate **90***a* and a vertical portion **92**B of the second side plate **94** connected to the second top plate **90***b* are not parallel to each other, and a distance between the vertical portion **92**A and the vertical portion **92**B gradually increases along a downward direction. The atomizer cover **42** thus has a shape that can be formed by integral molding of a resin.

A rectangular "Norseal" **100** is mounted to a distal-end-side back surface of the top plate **90** of the atomizer cover **42**, and a bolt mount **102** is mounted in a cutout which is formed in the base end. An elongated hole **102***a*, extending in the longitudinal direction of the atomizer cover **42**, is formed in the bolt mount **102**.

The atomizer cover **42** is fixed with one bolt (not shown) at a predetermined position by inserting a shank of the bolt into the elongated hole **102***a* of the bolt mount **102**, and fastening the bolt to bring a head of the bolt into contact with the bolt mount **102**. The mounting position of the atomizer cover **42** in its longitudinal direction can be finely adjusted through the elongated hole **102***a*.

The atomizer cover **42** has a smooth shape with no angular portion so that a liquid, which has come into contact with the inner or outer surface, can easily run down. Such a shape can prevent contamination of the atomizer cover **42** with a liquid including the polishing liquid. Moreover, even if the liquid including the polishing liquid has adhered to the atomizer cover **42**, the liquid can be easily removed. Furthermore, the atomizer cover **42**, because of its smooth shape with no angular portion, can be produced by integral molding of a resin.

As described above, the lower end surface **92***a* of the first side plate **92** connected to the first top plate **90***a* is inclined with respect to the horizontal plane X-X downwardly from the distal end toward the base end of the atomizer cover **42**. Similarly, the lower end surface **94***a* of the second side plate **94** connected to the second top plate **90***b* and the lower end surface **98***a* of the projecting portion **98** are inclined downward from the distal end toward the base end of the atomizer cover **42**. A liquid flows down from the semicylindrical top plate **90** to the side plates **92**, **94** and also flows down the projecting portion **98** to reach the lower end surfaces **92***a*, **94***a* of the side plates **92**, **94** and the lower end surface **98***a* of the projecting portion **98**. Because the lower end surfaces **92***a*, **94***a*, **98***a* are inclined with respect to the horizontal plane X-X, the liquid flows on the lower end surfaces **92***a*, **94***a*, **98***a* in the direction from the distal end to the base end of the atomizer cover **42**.

By providing the projecting portion **98** integrally on the second side plate **94** connected to the second top plate **90***b*, the atomizer cover **42** can be reinforced with the projecting portion **98**.

As shown in FIG. **7**, the top ring head cover **24** has a side cover **112** including a side plate **110**, and a lower cover **114** that closes a bottom opening of the side cover **112**. FIG. **12** shows the details of the lower cover **114**. As shown in FIG. **12**, the lower cover **114** includes a bottom plate **116** and a side plate **118**. The side plate **118** extends upwardly from a peripheral portion of the bottom plate **116** and surrounds, together with the side plate **110** of the side cover **112**, the top ring head **16**. The top ring **14** is coupled to the lower end of the top ring drive shaft **28** that extends downward through the bottom plate **116** of the lower cover **114**.

The bottom plate **116** of the lower cover **114** has such an inclination that, when the top ring **14** is in the polishing position above the polishing surface **10***a*, the bottom plate **116** is inclined downwardly toward a radially outward direction of the polishing table **12**. Specifically, the bottom plate **116** of the lower cover **114** is inclined downward in a direction toward the top ring head pivot shaft **26**.

The polishing liquid that has entered the interior of the top ring head cover **24** reaches the bottom plate **116** of the lower cover **114**, flows on the inclined bottom plate **116**, and is collected in a place beside the polishing table **12**. The polishing liquid can thus be prevented from contaminating the top ring head cover **24** and the top ring head **16**, and dropping onto and contaminating the polishing surface **10***a*.

FIG. **13** shows an enlarged cross-sectional view taken along line A-A in FIG. **12**. As shown in FIG. **13**, the upper end surface of the side plate **118** of the lower cover **114** is in contact with or in proximity to the lower end surface of the side plate **110** of the side cover **112**, and a "Norseal" **120** is attached to back surfaces of the side plate **118** and the side plate **110**. A gap between these side plates **110**, **78** is sealed by the Norseal **120**. Such a structure makes it possible to locate a coupling portion between the side cover **112** and the lower cover **114** at a higher position than a corner between the side cover **112** and the lower cover **114**. If the coupling portion between the side cover **112** and the lower cover **114** exists in the corner, the polishing liquid is likely to remain on the corner. The construction shown in FIG. **13** can solve such a drawback. Furthermore, the Norseal **120** can prevent intrusion of the polishing liquid into the top ring head cover **24**.

FIG. **14** shows a vertical cross-sectional view of the second dresser head cover **30***b*. As shown in FIG. **14**, the second dresser head cover **30***b* includes an upper side plate **122** and a lower side plate **124** each having approximately a cylindrical shape. A lower end surface of the upper side plate **122** is in contact with or in proximity to an upper end surface of the lower side plate **124**, and a tape **126** is attached to outer circumferential surfaces of the upper side plate **122** and the lower side plate **124**. A gap between the upper side plate **122** and the lower side plate **124** is sealed by the tape **126**. A buffer material **132** is disposed between a protrusion **128**, mounted to an inner circumferential surface of the upper side plate **122**, and a protrusion **130** mounted to an inner circumferential surface of the lower side plate **124**. With such a structure, a coupling portion between the upper side plate **122** and the lower side plate **124** can be located at a higher position and, in addition, a liquid can be prevented from intruding into the second dresser head cover **30***b*.

A curved-surface portion **120***a*, which smoothly connects a vertical portion to a horizontal portion of the upper side plate **122**, is formed at an upper portion of the upper side plate **122**. The curved-surface portion **120***a* allows liquid droplets to flow smoothly on the outer surface of the upper side plate **122**.

The first dresser head cover **30***a* may have the same construction as the second dresser head cover **30***b*.

FIG. **15** shows the details of the polishing liquid supply nozzle **46**. As shown in FIG. **15**, the polishing liquid supply nozzle **46** includes the pipe **50** and a plurality of polishing liquid tubes **134** housed in the pipe **50**. Such a structure can prevent intrusion of the polishing liquid into gaps between the

polishing liquid tubes **134** and can enhance the cleaning efficiency of the polishing liquid supply nozzle **46**.

The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

What is claimed is:

1. A polishing apparatus comprising:

a rotatable polishing table for supporting a polishing pad having a polishing surface;

an atomizer head configured to spray a cleaning fluid onto the polishing surface to clean the polishing surface; and

an atomizer cover that covers an upper surface of the atomizer head,

the atomizer cover including

a semicylindrical top plate having a semicylindrical shape, and

a first side plate and a second side plate extending downward from both lower ends of the semicylindrical top plate,

the semicylindrical top plate including

a first top plate having a vertical cross section in a shape of an arc whose radius is constant over its entire length from a base end to a distal end of the atomizer cover, and

a second top plate having a vertical cross section in a shape of an arc whose radius decreases gradually from the base end toward the distal end of the atomizer cover,

the first top plate and the second top plate being connected to each other at their top portions to constitute the semicylindrical top plate.

2. The polishing apparatus according to claim **1**, wherein the semicylindrical top plate, the first side plate, and the second side plate are formed integrally from resin.

3. The polishing apparatus according to claim **1**, wherein the first side plate and the second side plate have lower end surfaces, respectively, which are inclined downward from the distal end to the base end of the atomizer cover.

4. The polishing apparatus according to claim **1**, wherein the second side plate is connected to the second top plate, and the second side plate is provided with a projecting portion projecting in a horizontal direction.

5. The polishing apparatus according to claim **1**, further comprising:

a top ring head having a top ring configured to press a substrate against the polishing surface while holding and rotating the substrate; and

a top ring head cover surrounding the top ring head,

the top ring head cover including a side cover that surrounds the top ring head, and a lower cover that closes a bottom opening of the side cover,

the lower cover including a bottom plate inclined downwardly toward a radially outward direction of the polishing table when the top ring is in a polishing position above the polishing table.

6. The polishing apparatus according to claim **5**, wherein the lower cover includes a side plate which extends upwardly from a peripheral portion of the bottom plate and which is in contact with or in proximity to a side plate of the side cover.

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